VOL 63 NOV 2025

NTU Q

HIGHLIGHTING NEWS

OPTIMIZING THE NON-CLIFFORD-COUNT IN UNITARY SYNTHESIS USING REINFORCEMENT LEARNING

This paper presents a reinforcement learning (RL) framework for optimizing quantum circuit synthesis, specifically targeting reductions in non-Clifford gates such as T and CS gates. Since non-Clifford gates are expensive in fault-tolerant quantum computing, minimizing their number (the T-count or CS-count) is crucial. The authors introduce an RL-based algorithm that synthesizes exactly implementable unitaries using the Clifford+T and Clifford+CS gate sets. Their framework works with the channel representation of unitaries, representing them as integer matrices rather than complex-valued ones, which allows efficient matrix operations and significant reductions in computational complexity. They also implement pruning heuristics and canonicalization techniques to manage the search space effectively.

The results show that this approach can synthesize significantly larger unitaries than previous methods, achieving close-to-optimal decompositions for up to 100 T gates, about five times higher than prior RL-based algorithms. For 1-qubit unitaries, the RL algorithm recovers the known linear-time optimal results; for 2-qubit Clifford+CS unitaries, it achieves linear complexity comparable to the best-known SO(6)-based methods. Compared to existing synthesis algorithms, it runs faster, scales better, and produces circuits with lower non-Clifford counts. The authors conclude that their method not only represents the most scalable AI-based synthesis framework to date but also provides new insight into when efficient quantum synthesis algorithms may or may not exist.

READMORE (Paper)

QUANTINUUM'S HARDWARE IS NOW RUNNING QUANTUM TRANSFORMERS!

In July 2024, Quantinuum introduced Quixer (short for quantum mixer), a state-of-the-art quantum-native transformer built using quantum algorithmic primitives and tailored for quantum circuits. In June 2025, Quixer was reported to be running on Quantinuum's in-house quantum hardware.

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GOOGLE HAS ACHIEVED VERIFIABLE QUANTUM ADVANTAGE USING QUANTUM ECHO AND THE OTOC ALGORITHM

In October 2025, Google announced that its Willow quantum chip ran an out-of-order time-correlator (OTOC) algorithm that demonstrated a verifiable quantum advantage. Verifiable means that the algorithm can be repeated on the quantum hardware. It runs 13,000 times faster on Willow than the best classical algorithm on one of the world's fastest supercomputers. The algorithm consists of a four-step process on a 105-qubit array. The main idea is to send a series of forward operations (signals) to perturb one of the qubits of the chip, then the same series of operations in reverse to listen to the returning echo, followed by a measurement. In a proof-of-principle experiment, the algorithm was run to analyze two molecules of 15 and 28 atoms. The results matched those of a traditional NMR experiment.

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